



Technical Document 3242  
November 2010

# **Software Tools for Visual and Acoustic Real-Time Tracking of Marine Mammals: Whale Identification and Logging Display (WILD)**

Angela D'Amico  
Christopher Kyburg  
Rowena Carlson

Approved for public release; distribution is unlimited.

SSC Pacific  
San Diego, CA 92152-5001



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## Software Tools for Visual and Acoustic Real Time Tracking of Marine Mammals - WILD

Angela D'Amico,  
Christopher Kyburg,  
Rowena Carlson

SPAWAR Systems Center  
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San Diego, California

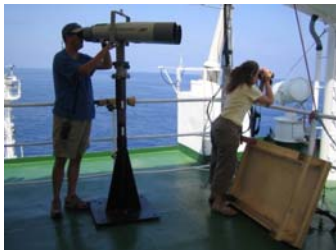


photo taken as part of research permitted under NMFS permit 14241



*9 November 2010*

## Wildlife Identification, Logging and Display (WILD) - Introduction

- ▼ WILD Functional Requirements
- ▼ NMEA – a short side trip
- ▼ Wildlife Identification Logging and Display (WILD) Software
  - Used for MED 09 and SOCAL-10 Sea Trials, Pinniped Surveys, San Diego Bay



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This talk will cover:

- the Functional Requirements that defined WILD
- a discussion of the National Marine Electronics Association 0183 standard and how it is used in WILD.
- a detailed description of the components of the WILD software and how they are deployed
- and finally an example of what you would see on the display as a Focal Follow unfolded.

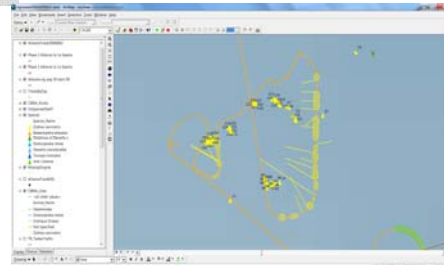
## WILD Software – Three Basic Components

Three main components:

- 1 - The Logger
- 2 - NMEA Distributor
- 3 - GIS Data Integration and Display

**WILD GIS Mapper**

**WILD Logger**



**NMEA Distributor**



**Other Data Streams**

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The WILD software is composed of three components:

- The Logger: This is used by the Visual Observers to record sightings of Animals, their behaviors, and environmental conditions.
- The NMEA Distributor: This component acts as the communications manager on the ship's network. It merges data streams from the Logger and all other instruments into a single feed which can be used anywhere on the ship's network.
- The Mapper: This is the display component of WILD. It operates within the ArcGIS Geographic Information System software suite. It extends the functionality of the standard ArcGIS environment to allow real time mapping of acoustic and visual animal observations as well as vessel locations etc.
- More on all three components later.

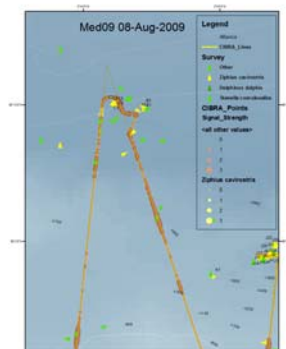
### ▼ Support Three Operational Modes

- 'Standard' Marine Mammal Survey Support
- Focal Follow / Tagging Support
- Mitigation Support

WILD Logger - Select Query

Observation	gsnTime	Observer	Range	Bearing	Species	BehavioralEvent
1A	9/5/2010 8:37:25 PM	Anne Douglas	1280.6		2 Physeter macrocephalus	logging
2A	9/5/2010 9:00:25 PM	Todd Pussar	1345.57		357 Physeter macrocephalus	surface/blow
3A	9/5/2010 9:03:40 PM	Anne Douglas	1182.8		0 Physeter macrocephalus	
4A	9/5/2010 9:05:25 PM	Bethany Diehl	1133.14		5 Physeter macrocephalus	fluke out
5A	9/5/2010 9:55:10 PM	Anne Douglas	1154.47		22 Physeter macrocephalus	logging
6A	9/5/2010 10:00:00 PM	Anne Douglas	1133.14		5 Physeter macrocephalus	fluke out
7A	9/5/2010 10:48:35 PM	Bethany Diehl	1133.14		285 Physeter macrocephalus	logging
8A	9/5/2010 10:55:10 PM	Bethany Diehl	829.81		3 Physeter macrocephalus	fluke out
9A	9/5/2010 12:00:40 AM	Stacy DeRutter	1000		50 Physeter macrocephalus	logging
10A	9/5/2010 12:45:10 AM	Todd Pussar	1000		320 Physeter macrocephalus	surface/blow
11A	9/5/2010 12:52:25 AM	Stacy DeRutter	700		260 Physeter macrocephalus	logging
12A	9/5/2010 12:53:15 AM	Stacy DeRutter	700		240 Physeter macrocephalus	fluke out
13	9/5/2010 1:15:50 AM	Stacy DeRutter	50		310 Grampus griseus	surface/blow
14	9/5/2010 1:13:35 AM	Bethany Diehl	3.8		320 Grampus griseus	surface/blow
15	9/5/2010 1:18:00 AM	Bethany Diehl	2210.74		330 Grampus griseus	surface/blow
16A	9/5/2010 1:20:40 AM	Bethany Diehl	2626.25		250 Physeter macrocephalus	
17A	9/5/2010 1:26:05 AM	Todd Pussar	1512.62		330 Physeter macrocephalus	
18A	9/5/2010 1:27:45 AM	Todd Pussar	1182.8		290 Physeter macrocephalus	
19A	9/5/2010 1:29:20 AM	Todd Pussar	1182.8		270 Physeter macrocephalus	
20A	9/5/2010 1:54:55 AM	Bethany Diehl	3325.58		290 Physeter macrocephalus	
21A	9/5/2010 2:04:50 AM	Anne Douglas	1913.42		0 Physeter macrocephalus	fluke out

Records: 14 of 21



- Data Stored Locally
- Send Animal Location to GIS
- Operate with Ship's Navigation Data
- Operate with 'Stand Alone' Navigation Data

The Functional Requirements of the system defined how each of the three components were to operate.

The Logger needed to support three operational modes:

- Survey mode, used for systematic marine mammal surveys used to gather data for density calculations
- Focal Follow mode: This mode is used in support of tagging observations
- Mitigation mode, used for post controlled exposure behavioral observations

In addition to the three operational modes the Logger is required to:

- Store all observation and environment data locally
- Broadcast visual animal observations over the ship's network
- Be able to use the ship's navigation system for positional data or use 'stand alone' navigation data.



## WILD Mapper Functional Requirements

### Provide a “tactical display system”

#### ▼ User interface

- Allow each user to customize view
- Provide each user with ‘standard’ GIS tools
- Allow other loggers to be integrated
- Integrate all vessels and observations – Real Time

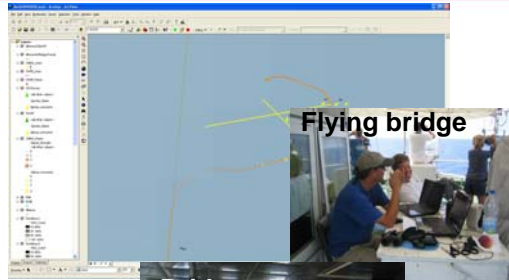
#### ▼ Data Management and networking

- Display at multiple locations on vessel – Real Time
- Easy integration of new sensors
- Save all observations locally

#### ▼ Display Base Map data

- Bathymetry (raster and vector contours)
- Raster nautical charts
- Planned survey track lines
- Marine sanctuary boundaries
- OPAREA boundaries

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Flying bridge



Bridge



Acoustic lab

The WILD display system had it's own set of functional requirements:

- Provide standard GIS tools and functionality.
- in real time.
- Display all observations and ship's positions integrated in multiple locations of the ship in real time.
- Allow users to manipulate their displays as desired.
- Save data locally
- Display base map data such as bathymetry, land, Survey track lines etc.

## National Marine Electronics Association Standard 0183 (NMEA 0183)

- ▼ NMEA 0183 standard defines a system to create data sentences for communications between marine electronics.

- ▼ Examples:

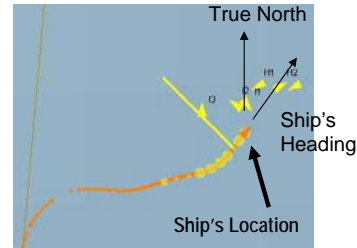
- Compass:

Diagram illustrating the structure of an NMEA 0183 sentence for a compass reading:

Sentence start → \$HEHDT,031.51,T\*1C <CR><LF>

Labels pointing to the sentence components:

- Sentence 'name' points to \$HEHDT
- Ship's heading points to 031.51
- 'T' indicating True North (not Magnetic North) points to T
- End of sentence points to <CR><LF>



- Ship's Location and Speed

Diagram illustrating the structure of an NMEA 0183 sentence for a location and speed reading:

\$GPRMC,050054,A,4123.6322,N,01103.7484,E,5.9,34.4,310809,1.4,E,A\*2E

Labels pointing to the sentence components:

- Time points to 050054
- Latitude points to 4123.6322,N
- Longitude points to 01103.7484,E
- Speed points to 5.9
- Date points to 310809

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In order for the Logger and other instruments to be able to transmit data to the Mapper a communications strategy was needed.

The National Marine Electronics Association created a standard for communicating data between electronic devices tailored to the marine environment known as NMEA 0183.


The standard allows equipment manufacturers to define data sentences for their instruments and broadcast them across a ship's network.

Two examples of these sentences are shown here.


The first is a bearing sentence produced by an electronic compass.

The second is a location sentence which has become a standard output of GPS instruments.

The instruments broadcast their respective sentences at between one and ten second intervals.



## NMEA - Custom Sentences



---

▼ Visual Species Observation:

\$PDONVSO,080809,071244,36.159509,-2.59928,0,Ziphius cavirostris,A,all down,118.38,2,1\*3B

Labels for Visual Species Observation sentence:


- Date: 080809
- Time: 071244
- Animal Latitude: 36.159509
- Animal Longitude: -2.59928
- Species: Ziphius cavirostris
- Behavior: A,all down
- Focal Follow Group: 118.38
- Number of Animals: 2
- Sighting Number: 1
- Checksum: \*3B

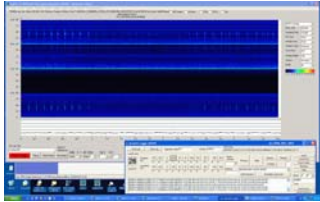
▼ CIBRA Passive Acoustic Detection Sentence (CIBRA Array):

\$PCIBRATA,310809,051600,41.41574,11.07641,14.77006,5.48,,,ZC,1,1,,,,E\*3C

Labels for CIBRA Passive Acoustic Detection Sentence:

- CIBRA Array: PCIBRATA
- Date: 310809
- Time: 051600
- Latitude: 41.41574
- Longitude: 11.07641
- Species: 14.77006
- Frequency: 5.48
- Species: ZC
- Animal Bearing: 1,1
- Checksum: E\*3C





▼ And other sentences for other sensors

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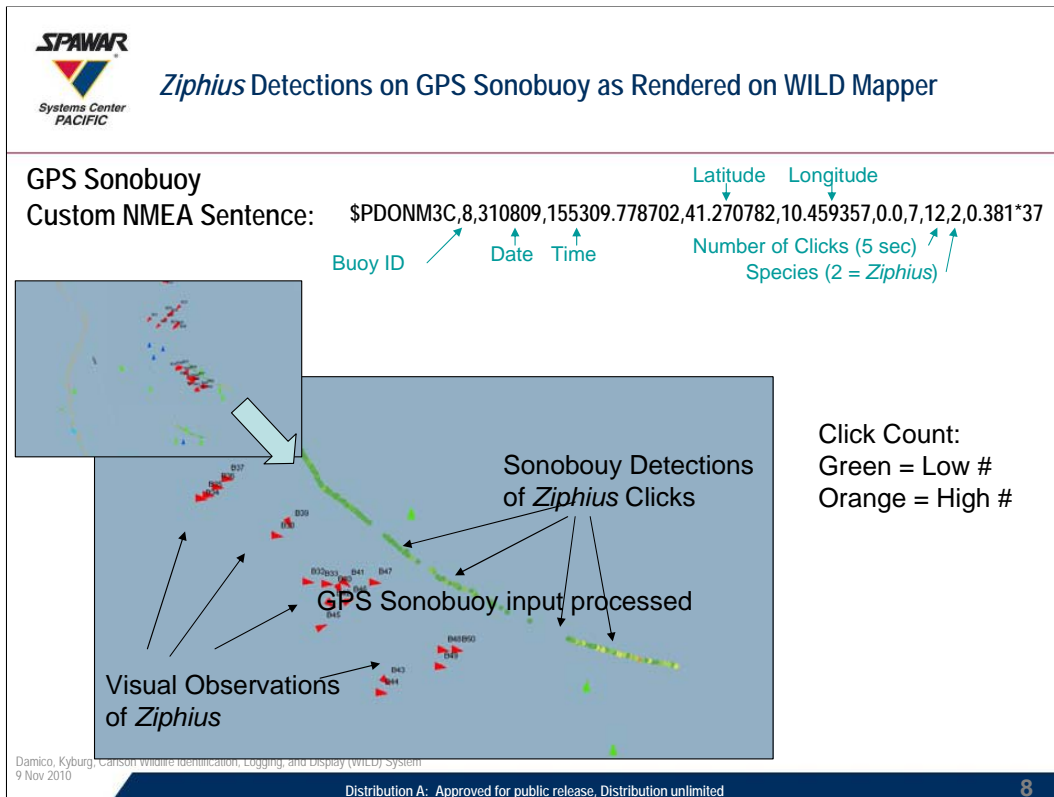
The NMEA 0183 standard was adopted for use in WILD and custom sentences were defined in accordance with the standard, and several are shown here.

The first is a Visual Species Observation sentence. All necessary data to plot the animal observation are provided in this sentence.

The second sentence is a used for passive acoustic detections using the CIBRA array created and operated by Gianni Pavan. Similarly the sentence provides all of the data required to plot the observation on the WILD Mapper.

The yellow triangles are how visual animal observations are rendered.

The yellow circles and lines are how acoustic animal vocalizations and bearings from the CIBRA array are rendered.




This is another example of a custom NMEA Acoustic sentence.

In this case it was designed to communicate GPS Sonobuoy detections.

All of the elements needed to render the observation in a meaningful way are included in the sentence

This shows how the Sonobuoy acoustic detections are plotted on the WILD Mapper display. The animal location is not determined so the detection is represented as a colored dot at the location of the buoy at the time of detection.



## WILD Logger - Environmental Observations Form

**PC Time**  
Date: 8/30/2009  
Time: 3:16:48 PM

**Env Status**  
Environment Update Due

**Follow Sample**  
Warning

**Platform GPS Data**  
Lat: N40° 22' 70.18"  
Lon: E10° 12' 21.38"  
Date: 30/08/09  
UTC: 14:16:50  
Hdg(m): 357.84  
Hdg(t): 357.84  
Spd(knots): 6.0

**Comm Status**  
GpsMode: UDP  
GpsPort: 5010  
Receiving: Yes  
Sat Signal: Valid GPS

**Output Database**  
Status: Open

Survey
Focal Follow
Environment
Mitigation
Notes

**PLATFORM GPS INFORMATION**

Date	Time	Latitude	Longitude	HDG(Mag)	HDG(True)	Speed(Kts)
30/08/09	14:15:56	N40° 22.6229'	E10° 12.2232'	357.57	357.57	6.0

**MODE**

☐ Focal Follow

☐ Mitigation

☒ On Effort - Off Track

☐ On Effort - On Track

☐ Off Effort

**CONDITIONS**

BeaufortScale	Swell (m)	Glare	Sightability
3	0_1	None	Good
Weather	Visibility (km)	Angle Min	
Clear	Good 5		
WindSpeed(Kts)	WindDirection	Angle Max	

**Vessels**

Ferries	Military Vessels
0	0
Sailing Boats	Motor Yachts
0	0
Fishing Boats	Cargo Ships
0	0

**OBSERVERS**

Stbd Big Eyes	Alt Binos	Recorder
Michela Podestà		Eletta Revelli
Port Big Eyes	Fwd Binos	
Todd Pusser	Nicolò Gavazzi	

**Notes**

Clear All
SAVE ALL (Alt + S)

Automatic display of ship status

Pull-down menus of standard observation information

Text boxes for input of other parameters

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Now let's take a closer look at the Three components of the WILD software system starting with the logger.

The Logger is comprised of a set of sub-forms for the various functions it performs:

The current position, heading and speed of the ship is continually displayed on the left side of the Logger display.

The Environmental form shown here is used to record sea state, weather, sightability and other relevant data such as vessels in the area and who is functioning in the various roles of the Visual Observer team.

By default this information is prompted for every 30 minutes.

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## WILD - Survey Mode Observations Form

*Survey Mode is along planned survey track*      *Multiple observation pages can be active*

Animal position is automatically calculated from ship heading, ship position, observation angle and observation Range.

Binocular menu includes 25x150 Bigeyes, 7x50 binoculars, and the naked eye.

Latitude and longitude of the animal is automatically sent to the GIS display as soon as "SAVE ALL" button is pushed.

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The WILD Logger's Survey form is shown here.

When an animal is seen an observation record is started by pressing the "Load GPS Start Time" button

At a minimum, the species name, the bearing to the animal, the distance or reticle and the best guess of the number of animals are required. Other information may optionally be entered.

When the "Save All" button is pressed, the information is saved to the local database, and the Visual Species Observation sentence is generated and broadcast across the ship's network.

Note that multiple observations can be open at the same time.

## WILD – Focal Follow Mode Observations Form

*Focal Follow Mode generally involved deviation from the planned survey track to follow a selected animal or group of animals*

Specialized input format for Focal Follow mode

5 minute behavior form

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This is the WILD Logger's Focal Follow Observation Form.

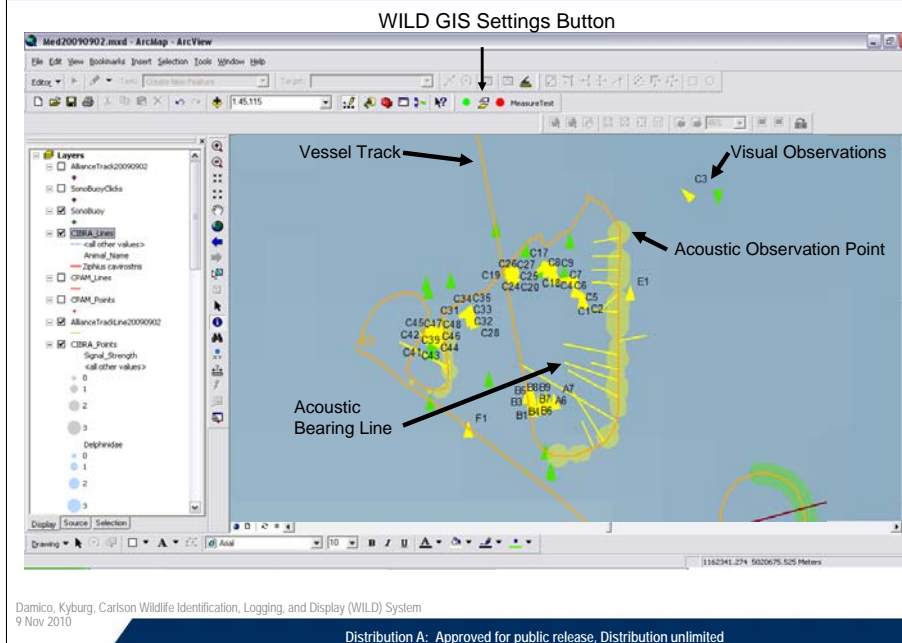
The form is very similar to the Survey form with the following differences:

A group identifier and observation number are assigned to a series of observations of one or more animals. This allows the observations to be seen as one or more series of observations of an individual or group through time.

The Lower part of the form is used to record behavior periodically in order to help document changes in group behavior.

Note that observations of multiple groups can be worked on at the same time.






This is the WILD Mapper display.

When operating the Mapper 'listens' on the network for NMEA sentences and renders objects on the map as they are detected.


The orange line is the ship's track, the triangles represent visual observations, and the circles and lines represent acoustic observations. Both visual and acoustic observations are color coded to represent the species observed.






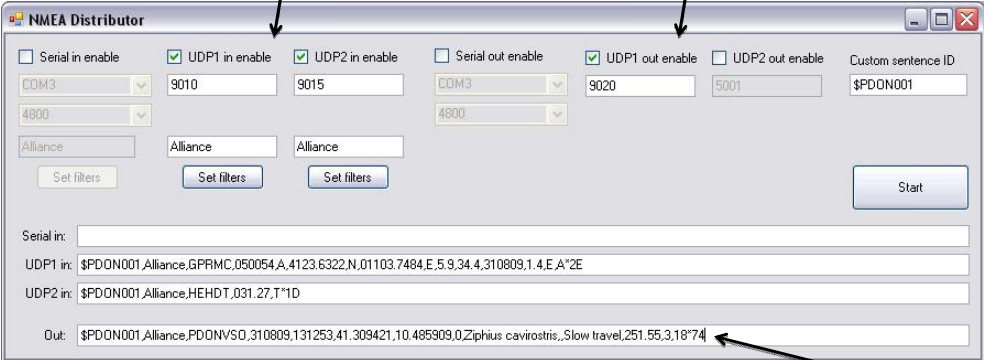
## WILD - NMEA Distributor

Signal in setup



Signal out setup





Signal out with all sighting information

- NMEA distributor for each system (ship GPS, towed array, assist boat GPS, visual observations, etc)
- Many instances can run on many machines to support potentially complex environments

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This is the NMEA distributor.

It is the communications building block of the WILD system.

In it's simplest form it accepts two data streams and merges them into one.

Multiple distributors can be used to merge any number of instruments into one data stream

It is also used to convert a serial signal (which is what most instruments output) into a UDP broadcast stream, allowing it to be picked up and used anywhere on the ship's network.

## WILD – Settings Form

The screenshot shows the 'Settings' window for the WILD system. It is organized into several panels:

- GPS IN:** Features two radio buttons: 'UDP Input' (which is selected) and 'Serial Input'. Below the radio buttons is a 'UDP IN' section with a 'Port' field set to '6000'.
- DATA OUTPUT:** Features two checkboxes: 'UDP' (checked) and 'Serial'. Below the checkboxes is a 'UDP OUT' section with a 'Port' field set to '6500'.
- COMPASS IN:** Features two radio buttons: 'UDP Input' and 'Serial Input' (which is selected). Below the radio buttons is a 'UDP IN' section with a 'Port' field set to '5000'.
- Binocular Reference Heights:** Contains two text input fields: 'Default Observer Height (m):' with the value '1.26' and 'Bridge Height (m):' with the value '5.46'.
- Data Directory:** Shows the current directory as 'C:\Users\Public\WildData\' with a 'Change Directory' button below it.
- Environment Update Interval:** A section on the right with a '30' minute interval.
- Buttons:** At the bottom of the window are three buttons: 'OK / SAVE', 'APPLY', and 'CANCEL'.

The WILD Logger setup form allows parameters such as platform height, communications parameters, and data storage location to be set.

- Vessel Locations can be from GPS or AIS

The image displays two windows from the WILD Mapper software. On the left is the 'VesselEdit' window, which contains fields for 'Vessel Name' (Truth), 'Location Sentence' (GPRMC), 'Compass Sentence' (GPHDT), 'AIS MMSI' (987654321), 'ArrowMarker' (checked), 'Track With AIS' (GPS), 'Color' (green), and 'Point Freq. (sec)' (10). On the right is the 'Settings' window, which is divided into several sections: 'Vessel Settings' (Source: Vessels, Sentence Identifier, Color, Vessel Point Freq. (Sec): 10), 'Visual Observation Settings' (Visual Observations: Via Obs. Survey, Via Obs. Focal Follow, POONVSO), 'Acoustic Observation Settings' (Acoustic Observations: M3R, CIBRA, CPAM, MDS, POONMOR, PCIBRATA, PNURCPAM, POONMGS), and 'Communications Settings' (Communication Parameters: File, Serial, TCP, UDP, Port: 7000, Baud Rate: 38400, Data Folder: c:\Users\Public\WildGISData). Arrows point from the 'VesselEdit' window to the 'Settings' window, and labels on the right side of the 'Settings' window identify each section.

The WILD Mapper settings forma allows similar information to be set for the Mapper in addition to managing the project vessel list and parameters.

**Initializer:** checks to see if a Geodatabase exists for the current date. If not, creates one from the seed GDB (enables 24 hour operation, unattended).

**Renderer:** Sets display parameters and updates the display.

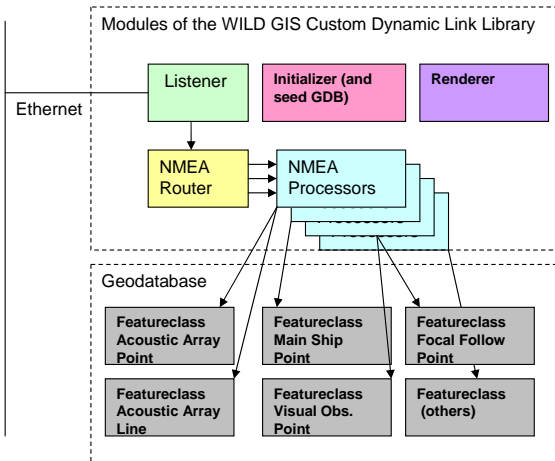
Step 1. DLL Receives signals broadcast over the ship's network by the NMEA distributors.

Step 2. UDP Listener captures NMEA sentences and checks compliance with 0183 standard.

Step 3. NMEA Router passes sentences to the correct NMEA Processor based on the sentence identifier.

Step 4. NMEA Processor extracts latitude, longitude and all other attribute data from the sentence and creates the feature. The feature class is then updated in the Geodatabase.

Step 5. WILD GIS display is then updated with the newly received data point or line.



This is a schematic of the NMEA Mapper's objects.

The listener sends valid NMEA sentences to the Router.

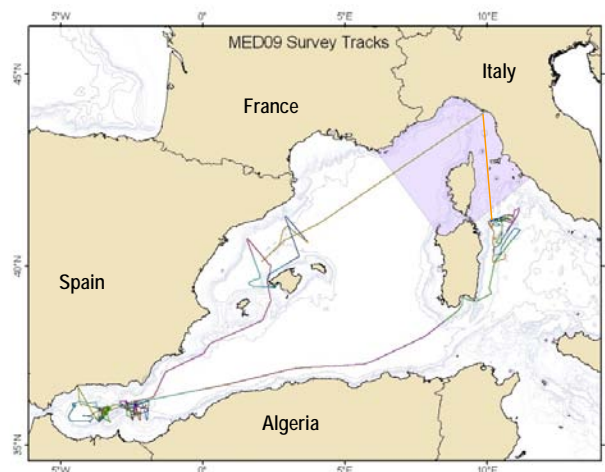
The Router determines what type of sentence it has from the sentence name and routes the sentence to the correct NMEA processor.

The Processor creates the feature in the correct feature class and stores it in the Geodatabase.

Periodically the renderer refreshes the map with the new feature(s).

The initializer will create a new Geodatabase when the application is started if one does not already exist.

## WILD System Configuration Aboard NR/V Alliance MED 09



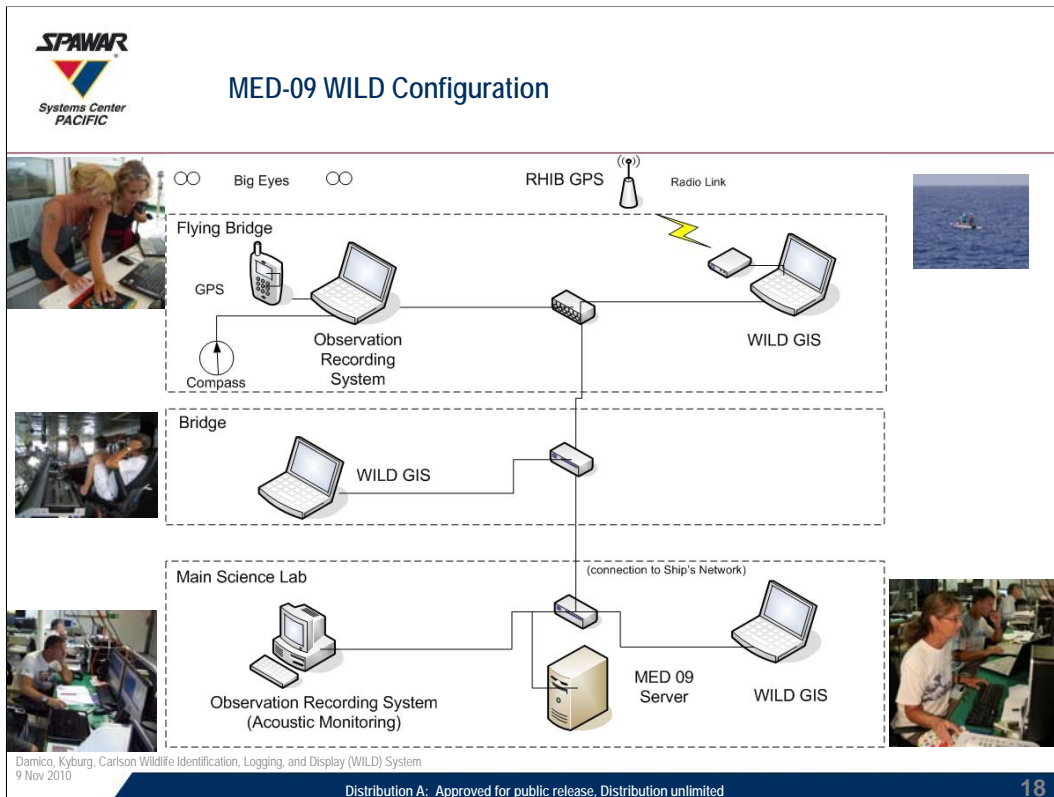
The objective of MED 09 was the detection of beaked whales and pilot whales in the western Mediterranean to evaluate abundance and dive behavior. See <http://med09-expedition.blogspot.com/>

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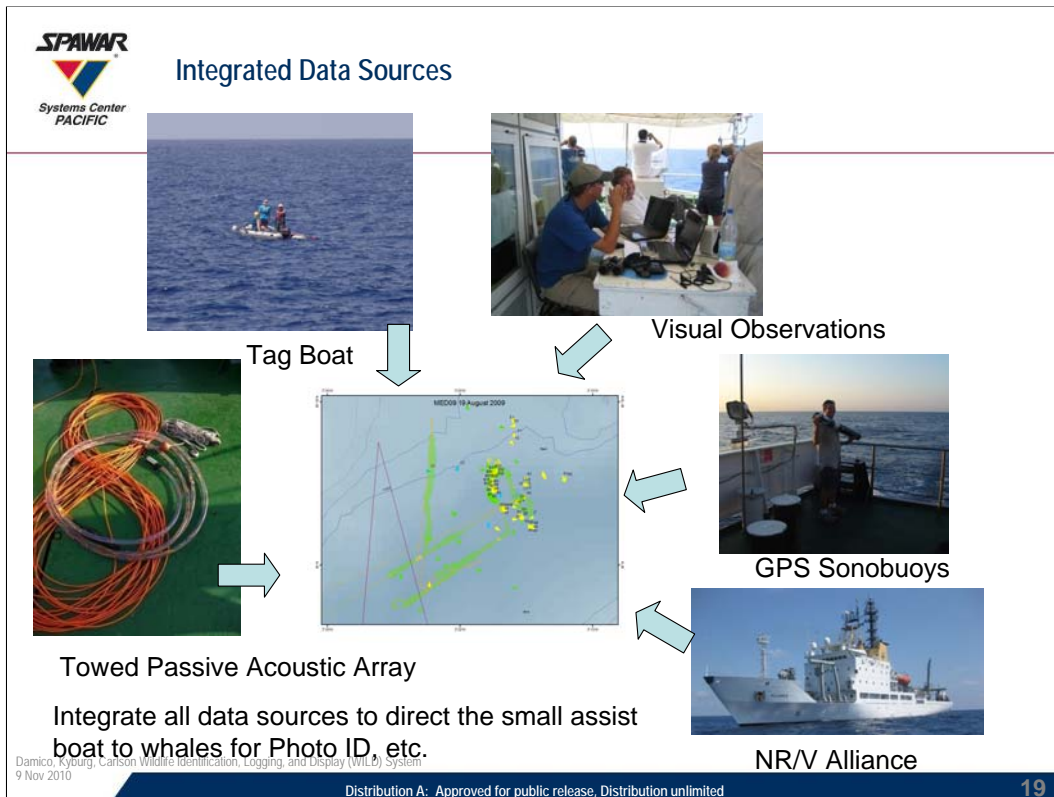
**17**

The MED-09 cruise involved multiple acoustic detection systems and visual operations in a sophisticated network.



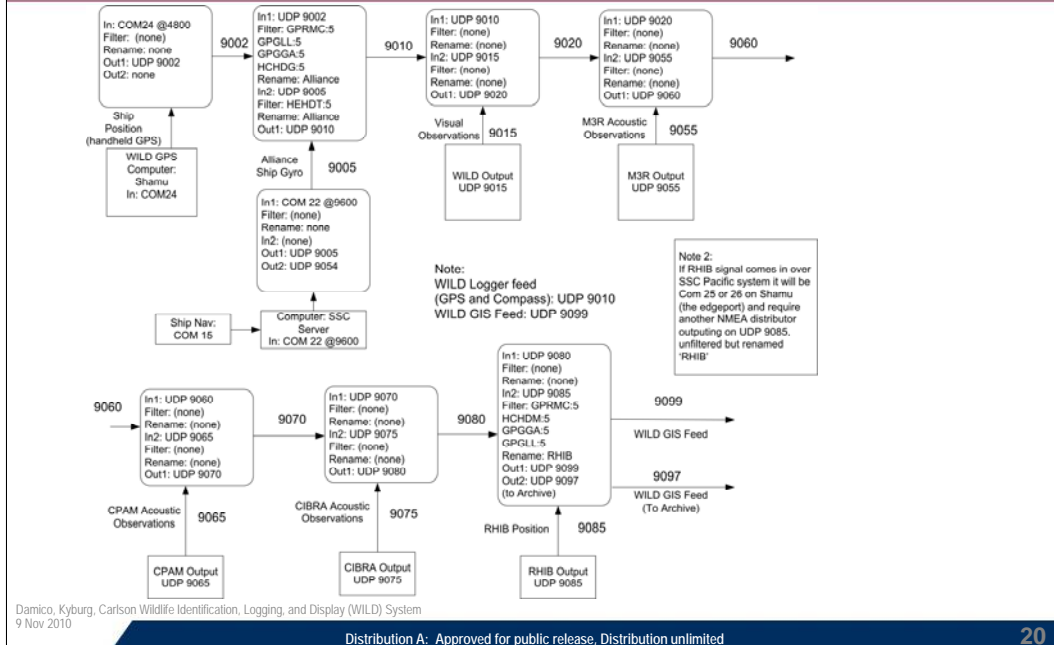
The system involved three WILD displays one in the acoustic lab, one on the bridge, and a third on the flying bridge.

On the NR/V Alliance either the acoustic or visual teams requested the ship to modify its location based on whether the animals were on the surface or at depth vocalizing so detections would be optimized.



A variety of data was integrated into the WILD Mapper aboard the Alliance including Tag boat location, visual observations acoustic detections from sonobuoys, the main Research platform Alliance, and acoustic detections from the CIBRA array.

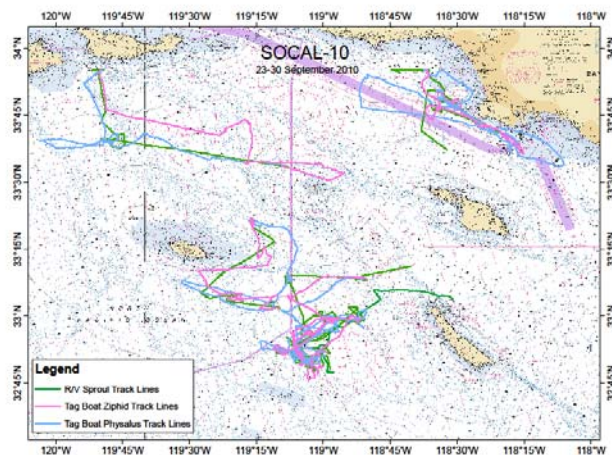
## NMEA Distributor setup aboard NR/V Alliance



The network of NMEA Distributors needed to merge all of the information of interest was quite complex but worked very well



## WILD System Configuration Aboard Truth and R/V Sproul SOCAL-10



The objective of SOCAL-10 was to contribute to understanding of marine mammal behavior and changes in behavior as a function of sound exposure for various species. See <http://sea.typepad.com>

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The WILD system used in SOCAL-10 was much simpler, as visual observations were the primary detection method.

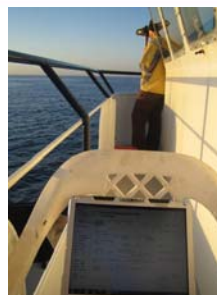
## SOCAL-10 WILD Stand Alone Configuration (R/V Sproul)



GPS Heading Sensor



WILD Logger Station



AIS Receiver, WiFi Router



WILD Mapper GIS Station

Several of the changes from the MED-09 to the SOCAL-10 system include use of a GPS compass, use of WiFi in the ship's network, and IAS transponders to track the tag boats.

## MED 09 Daily Summary Example

Species: *Ziphius cavirostris*

Group identifier: J

Location: 36° 10'N; 2° 38'W

Duration: 4:49 (1525 to 2014)

Group composition: 4 animals (3 adults, possibly female; 1 juv.)

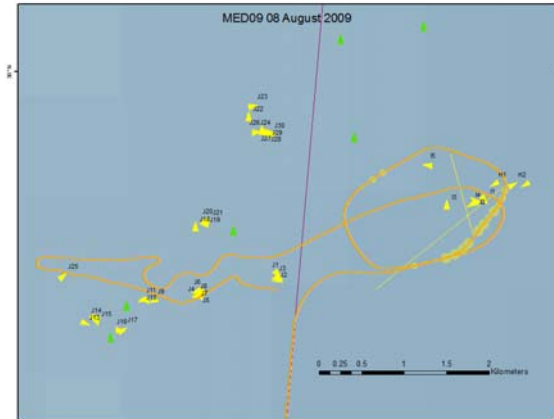
Number shallow dives: 5

Avg. shallow dive time: 20.6 min

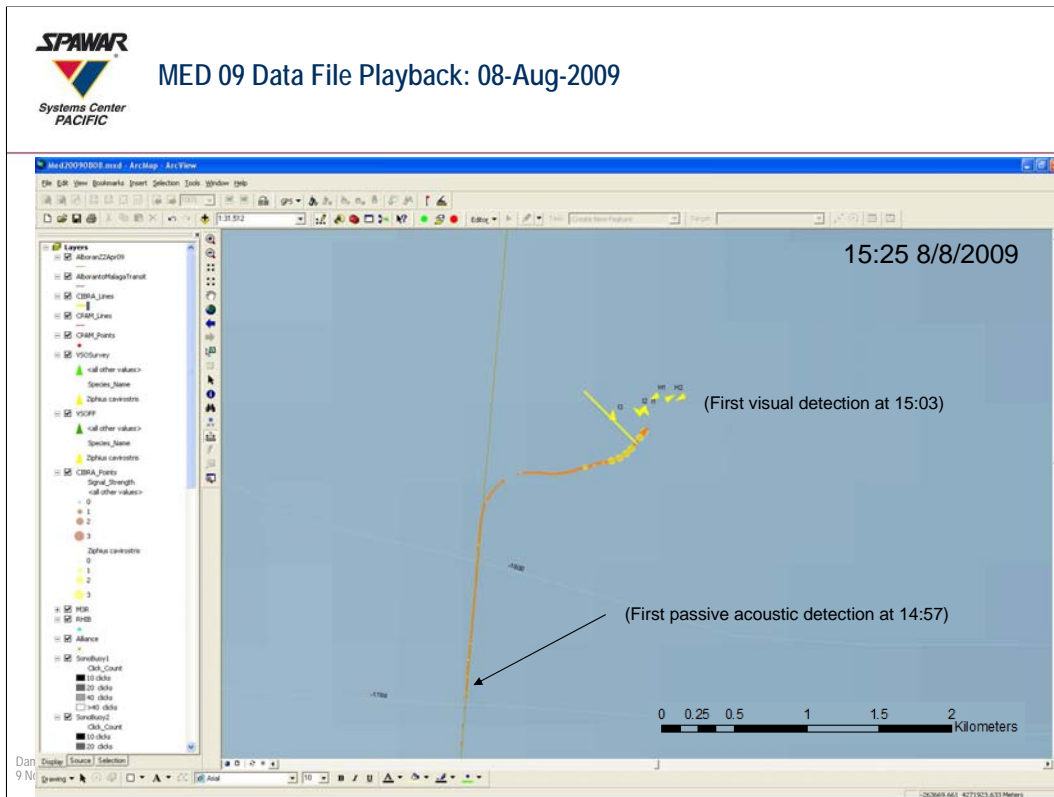
Avg. distance between dives: 648 m

What ended follow: SUNSET

Comments: Good follow and on animals with good tracking, just ran out of light

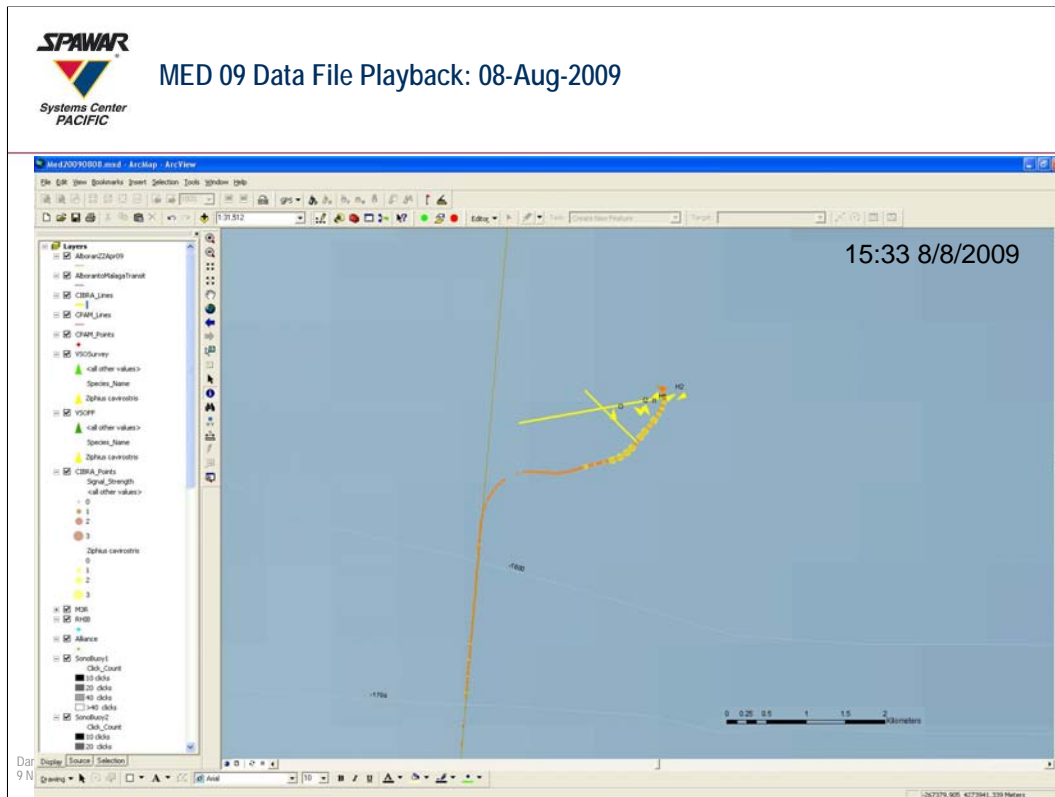


The following set of slides give you an idea of what the WILD display looks like through a typical Focal Follow tagging attempt.

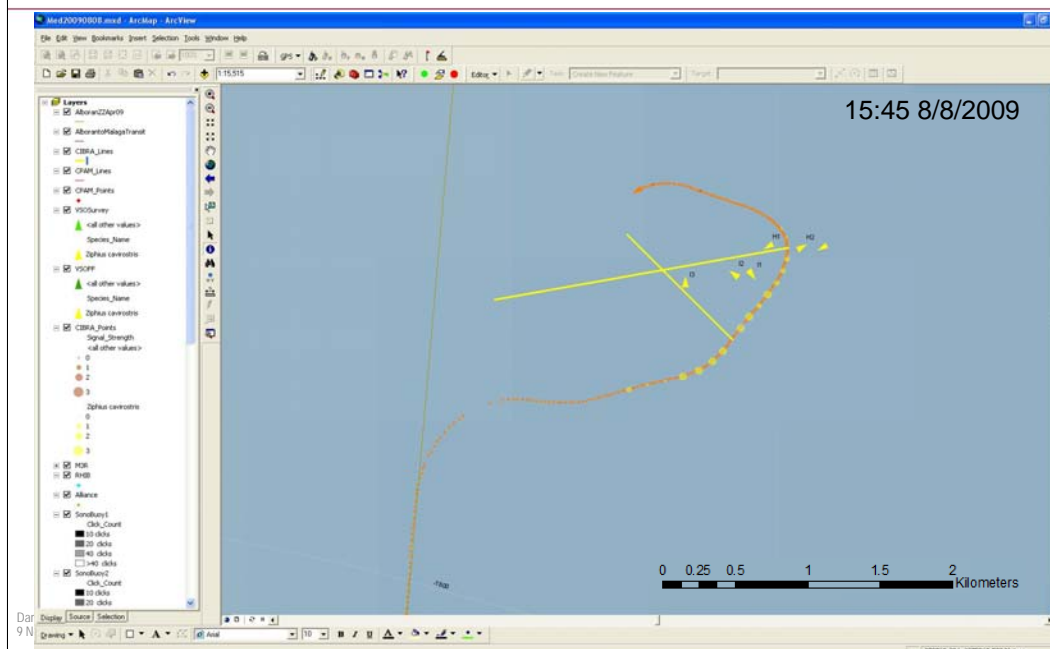


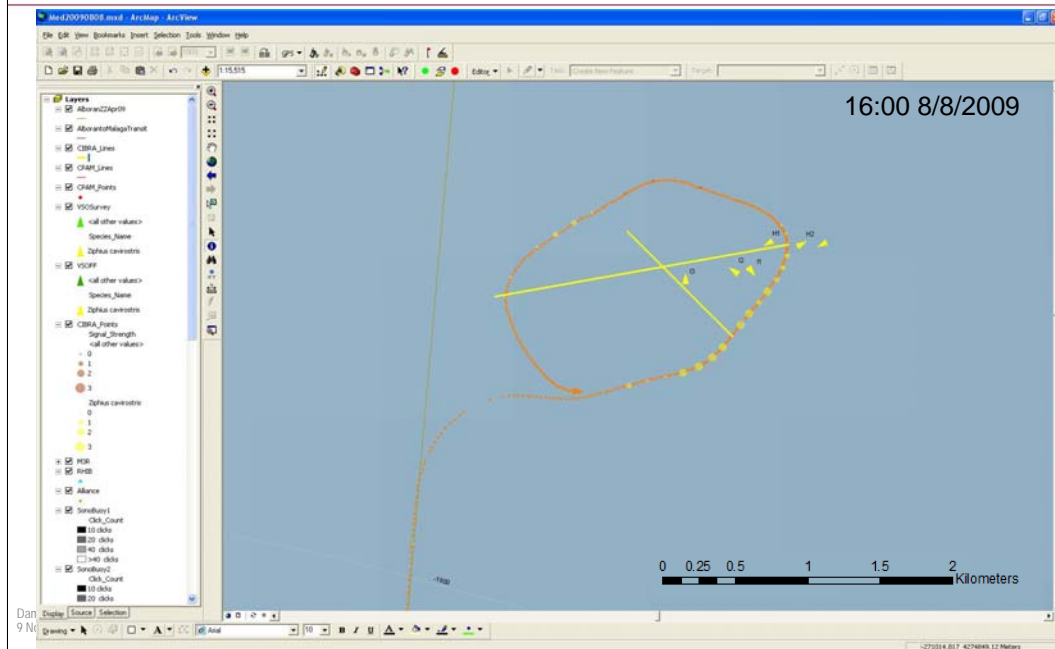
Beaked whales were initially detected on the passive acoustic towed array and the decision was made to change from Survey mode to Focal Follow mode and attempt to locate the animals.

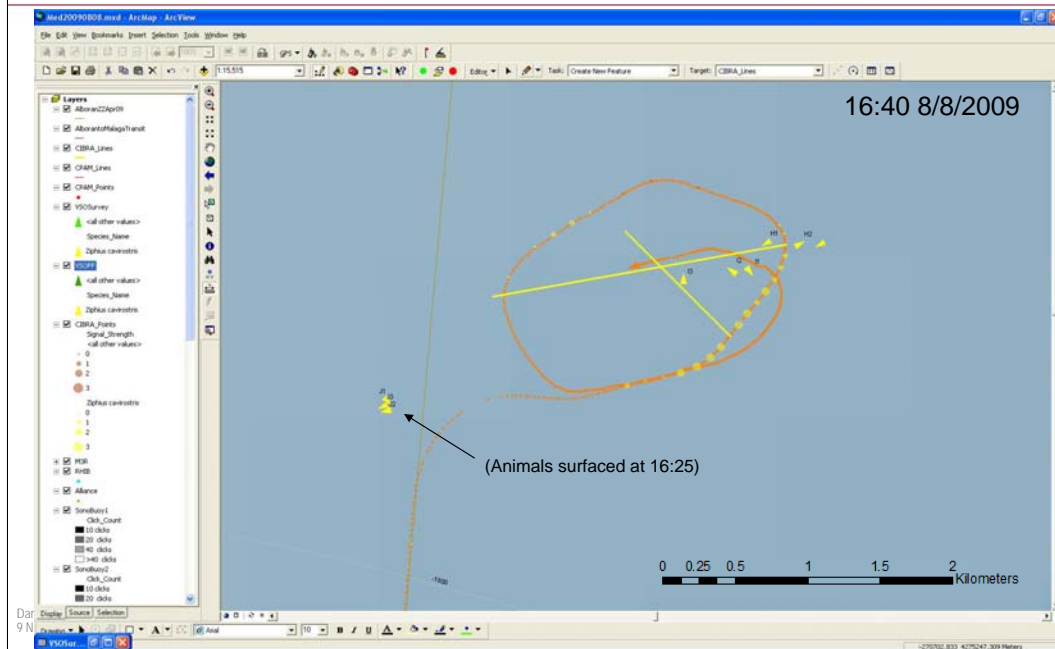
The animals were seen and the Alliance headed in the direction of the observations. As the ship makes it's way to the area the animals were seen they dove and were picked up on the acoustic array again.



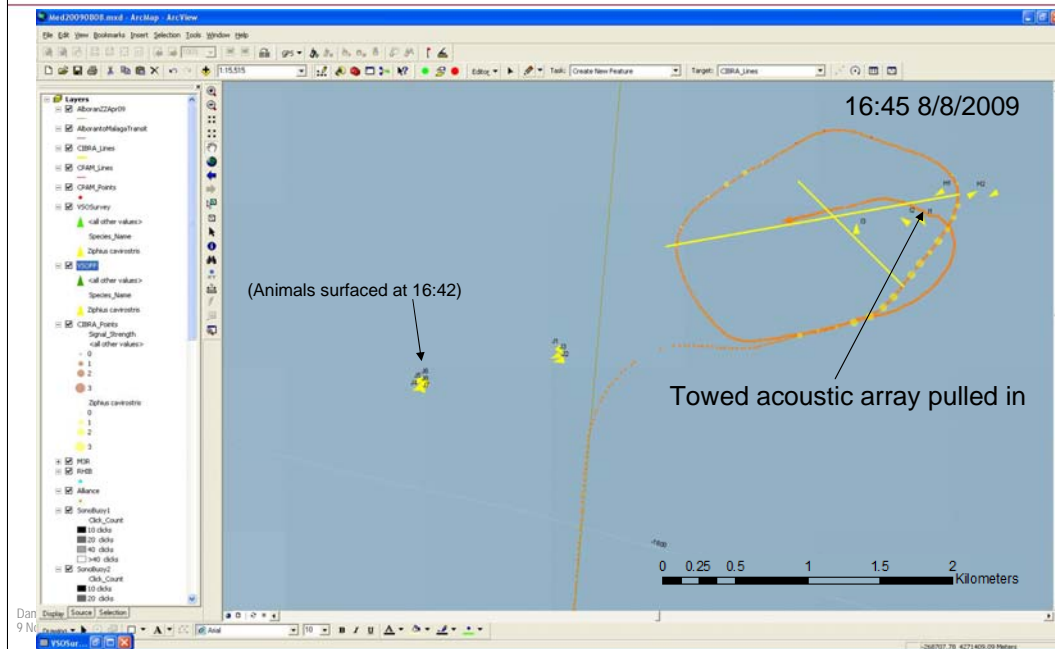
The chase progressed throughout the afternoon and into the evening.



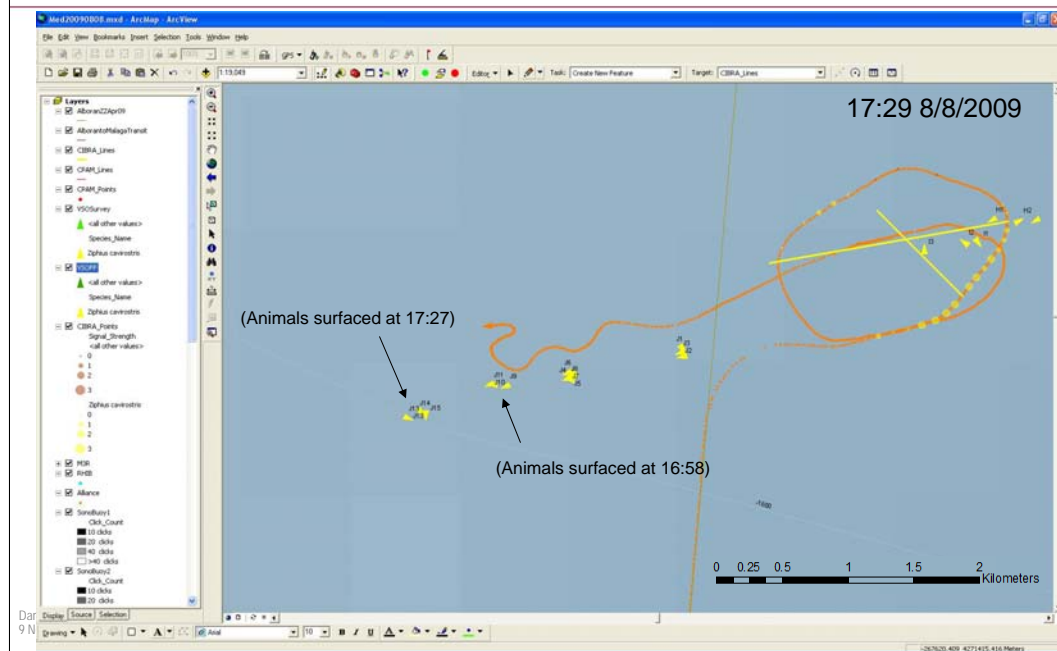




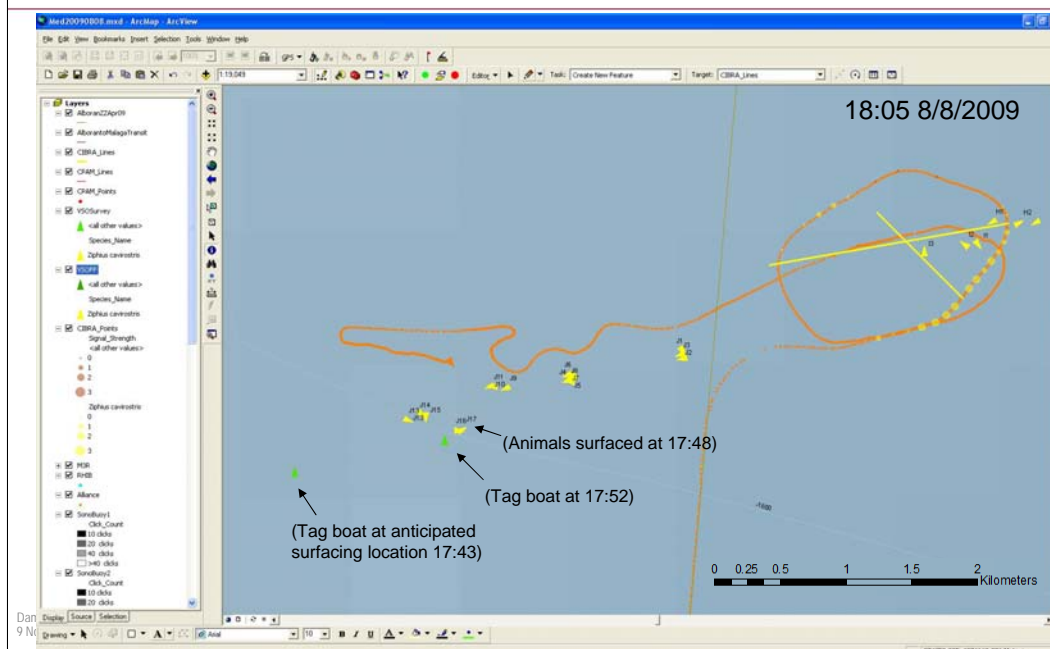


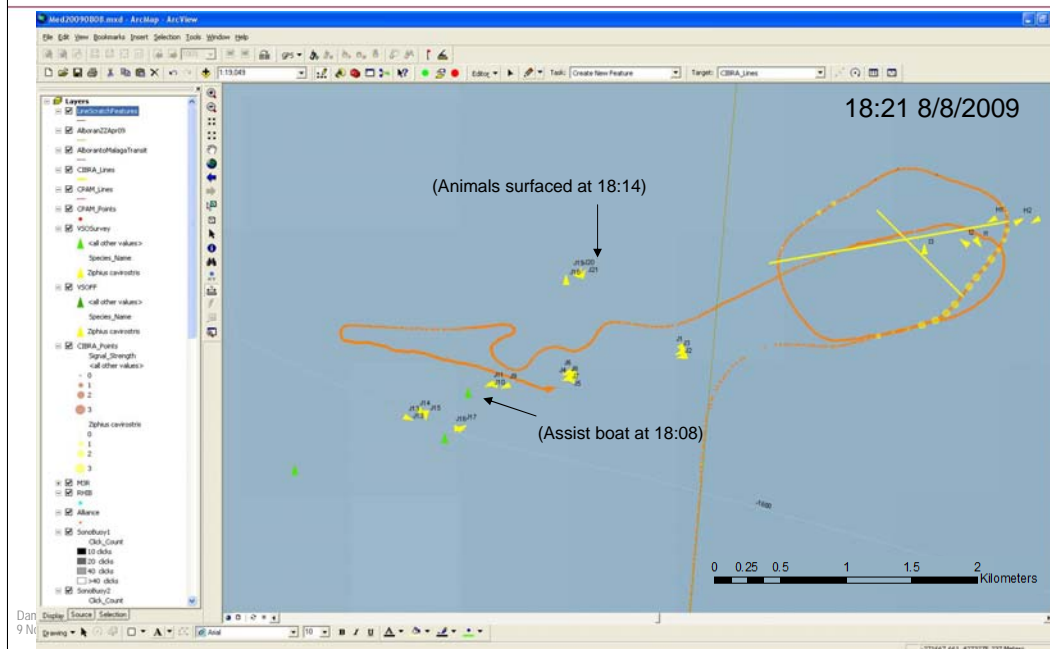


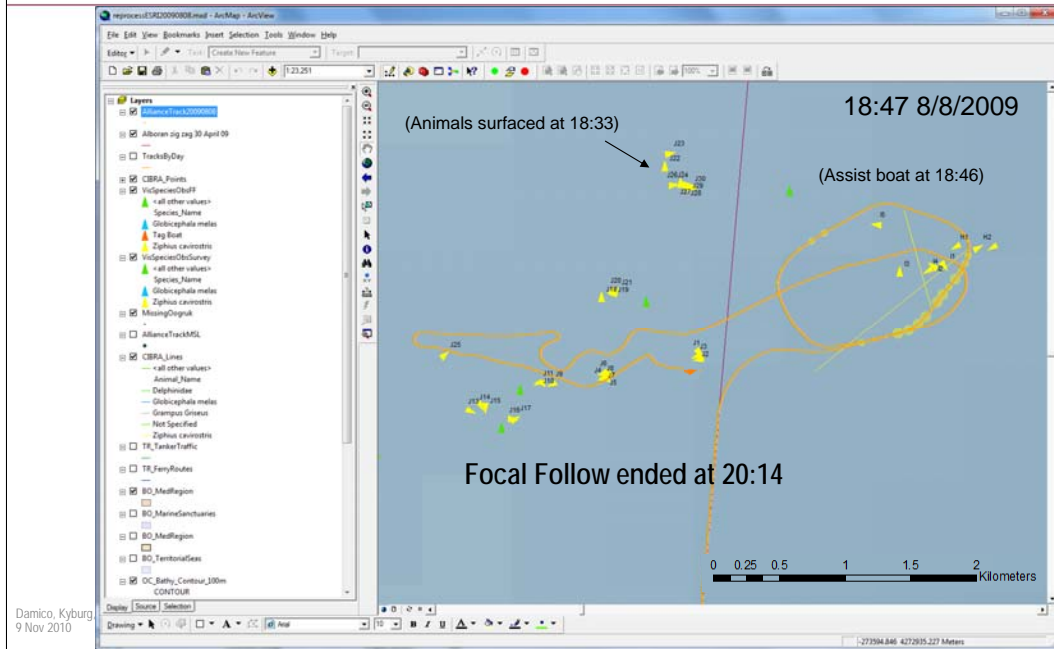
Following the third surfacing the towed array was shipped to allow the vessel to maneuver better.



The visual team attempts to keep the vessel in a position to maximize the ability to see the animals surfacing based on glare etc.







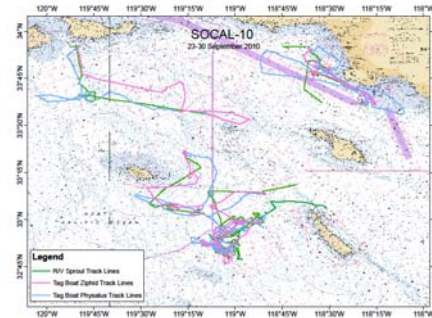
The Focal Follow was ended at 20:14 UTC due to loss of daylight.

▼ SOCAL 10 Sea Trials

- Used AIS transponders instead of radio link for small boat tracking.
- Small vessel vs 'conventional' Research vessel

▼ Cursory Results:

- 26 playbacks
  - 18 blue whale
  - 5 fin whale
  - 2 sperm whale
  - 1 beaked whale
- 3 control



The first year of the SOCAL-10 sea trials were very productive. Lessons learned will be incorporated into the subsequent fieldwork.

## Acknowledgments



### ▼ MED 09 and SOCAL-10 Sponsors

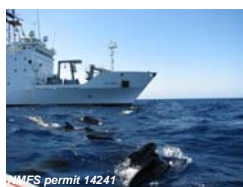
- ONR
- CNO N45

### ▼ MED09 team

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### ▼ SOCAL-10 team

- WHOI, SSC Pacific, Cascadia Research Collective, SEA Inc., Duke University, NUWC, SWMFS Southwest, Scripps, Applied Physical Sciences, U.C. Santa Cruz



The team wants to thank the participants and sponsors.



# Thank You!

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Questions?

Damico, Kyburg, Carlson Wildlife Identification, Logging, and Display (WILD) System  
9 Nov 2010

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Thank you!



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14. ABSTRACT					
This technical document covers the functional requirements that define Wildlife Identification, Logging and Display (WILD), National Marine Electronics Association (NMEA) 0183 standard and how it is used in WILD, components of the WILD software and how they are deployed, and what is seen on the display as a Focal Follow unfolded. The WILD software is composed of three components. The first component is the Logger. The Logger is used by the visual observers to record sightings of animals, their behaviors, and environmental conditions. The second component is the NMEA Distributor. The NMEA Distributor acts as the communications manager on the ships network. It merges data streams from the Logger and all other instruments into a single feed that can be used anywhere on the ship's network. The third component is the Mapper. The Mapper is the display components of WILD. It operates within the ArcGIS Geographic Information System software suite. It extends the functionality of the standard ArcGIS environment to allow real-time mapping of acoustic and visual observations as well as vessel locations, etc.					
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WILD Mapper					
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